CHAPTER I
INTRODUCTION

Hydrogen is considered as an attractive energy carrier because of the lack of environmental pollutants generated compared with conventional fossil fuels sources. One potential use of hydrogen lies in powering zero-emission vehicles via a proton exchange membrane fuel cell to reduce atmospheric pollution (Cheng *et al.*, 2001). To achieve this goal, onboard hydrogen storage systems have to be developed.

Hydrogen storage techniques include gaseous hydrogen storage, liquid hydrogen storage, and solid hydrogen storage. A major drawback of the gaseous storage for onboard hydrogen storage is high pressure and small amount of hydrogen that can be stored in a reasonable volume. For the liquid hydrogen storage, a large quantity of energy is required for liquefaction (Zhou, 2005). So the first two hydrogen storage techniques are inconvenient to apply with onboard hydrogen storage.

For the solid state storage, carbon nanostructures (Dillion *et al.*, 1997; Poirier *et al.*, 2001), activated charcoal (Carpetis and Peshka, 1980; Agarwal *et al.*, 1987), and metallic hydride (Sandrock *et al.*, 1992) have been investigated as hydrogen carriers. Nevertheless, their disadvantages include low hydrogen capacity, too high of adsorption/desorption temperature, low kinetic rate and low reversibility. To meet the U.S. Department of Energy (DOE) requirement for at least 550-kilometer drive, materials that can reversibly adsorb large amounts of hydrogen up to 6.5 wt% (the ratio of stored hydrogen weight to system weight) are needed (Tibbets *et al.*, 2001).

Many attempts have been made to improve and identify materials that can be applied for onboard hydrogen storage for fuel cell. The operating condition requirements for effective hydrogen storage for fuel cell transportation include: (1) appropriate thermodynamics (ambient temperature for absorption and desorption), (2) fast kinetics, (3) high storage capacity, (4) low cost, (5) effective heat transfer, (6) high gravimetric and volumetric densities (light in weight and conservative in space), (7) long cycle lifetime for hydrogen absorption and desorption, (8) high

mechanical strength and durability, and (9) safety under normal use (Grochala and Edwards, 2004).

Carbon nanostructures (nanostructure graphite, nanotubes, nanofibers and more recently, fullerenes or "bulky balls") are considered to be materials with high potential for reversibly storing large quantities of hydrogen. One candidate of carbon nanostructures for a hydrogen storage medium is nanostructure graphite that represents a great economic and has the potential to store hydrogen under moderate temperature and pressure conditions (Lueking *et al.*, 2004; Biris *et al.*, 2004). Furthermore, graphite cans uptake very high hydrogen capacities owing to the low specific weight of the carbon (Chambers *et al.*, 1998). Nevertheless, the DOE energy density target has not been reached yet and the desorption temperature is very high. Therefore, more understanding on the desorption is needed for further development of hydrogen storage medium.

In this study, graphite was selected as a base material for hydrogen storage. Nanostructure graphite was prepared by mechanical ball milling. In addition, transition metals (Zr, V, Ti, and Fe powder) and an alkali earth (K) were doped into the base material to study their effects on the hydrogen storage capacity.